



Transportation Synthesis Report

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Whitetopping Performance and Mechanistic Design

Prepared for
Rigid Pavement Technical Oversight Committee
Wisconsin Highway Research Program

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Transportation Synthesis Reports are brief summaries of currently available information on topics of interest to WisDOT technical staff. Online and print sources for TSRs include NCHRP and other TRB programs, AASHTO, the research and practices of other transportation agencies, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.

Request for Report

The Rigid Pavement TOC of the Wisconsin Highway Research Program requested a summary of research and practice in evaluating the performance of whitetopping and developing mechanistic design guidelines and procedures for whitetopping.

Summary

Whitetopping drew significant attention from transportation agencies in this country in the 1990s as a technique for cost-effective, durable rehabilitation of asphalt pavements. The practice has since extended to rehabilitation of concrete pavements as well. Thin whitetopping involves concrete overlays of 4 to 8 inches, which in most cases require bonding to the surface of the pavement to be overlaid. Ultra-thin whitetopping involves overlays of 4 inches or less, which must be bonded to the underlying surface.

From the numerous studies and findings available on whitetopping we selected those most related to performance and mechanistic design. In recent years, several state transportation agencies have focused on mechanistic design of whitetopping by gathering performance data, conducting mechanical tests of mixes and whitetopping installations, and preparing inputs for use with the AASHTO Mechanistic-Empirical Design Guide under review nationwide. WHP's interest in this topic is timely, and is well shared in the north central region. Minnesota stands as a clear leader in developing mechanistic design of whitetopping; Iowa has been using whitetopping extensively for a number of years; and Illinois has included whitetopping in its in-state mechanistic-empirical design practices. Colorado DOT has also put significant energy in the last 10 years toward mechanistic design of whitetopping.

This synthesis reviews these efforts and others around the country. Starting with **National and Regional** research, we look at an NCHRP synthesis report, at FHWA information on whitetopping, and at recent national-level reports in TRB's *Transportation Research Record* on whitetopping across the United States. We also cite a proposed pooled fund study led by Minnesota DOT, and a WisDOT Transportation Synthesis Report on regional efforts in concrete pavement research that includes work on whitetopping from Wisconsin and neighboring states.

This report highlights studies and articles from **Minnesota DOT** on its efforts to develop mechanistic and performance-based whitetopping design guidelines, as well as publications from, in alphabetical order, **Colorado, Illinois, Iowa and Michigan**, and two **Other States**, and **Industry** information on whitetopping.

National and Regional

On a national and regional level, whitetopping was the topic of a recent NCHRP synthesis report that includes 37 states. FHWA has devoted some of its Concrete Pavement Technology Program efforts to whitetopping, and two reports from TRB's *Transportation Research Record* review whitetopping for a national audience. This section also highlights a pooled fund study and a WisDOT Transportation Synthesis Report.

NCHRP Synthesis 338, Thin and Ultra-Thin Whitetopping, 2004.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_338.pdf

This study included a survey of state DOTs and other organizations, with 37 states, five provinces, and seven industry groups responding. The report includes extensive information on whitetopping design and construction and more limited information on performance, performance assessment, maintenance and rehabilitation. Highlights include:

- Typical distresses include early-age uncontrolled cracking, shrinkage cracking, joint edge spalling and raveling; and long-term longitudinal, transverse and corner cracking, faulting, and surface wear.
- A review of performance assessment and inspection methodology—see Chapter 6, pages 34-39.
- Cost-analysis suggestions for maintenance and rehabilitation—see pages 40-41. Performance data has not been collected extensively for whitetopping.
- Survey results included:
 - More than half of U.S. states have constructed whitetopping within last five years,
 - More than 40 percent have constructed whitetopping within last year,
 - Light to heavy traffic situations.

Survey results are summarized in Appendix A, pages 51-65; performance is addressed in questions 35-40 on pages 62-65.

FHWA—Concrete Pavement Technology Program. Of the program's six focus areas, whitetopping and ultra-thin whitetopping are included in CPTP Focus Area 1, Advanced Designs. See Chapter 2 of a February 2004 status report at <http://www.fhwa.dot.gov/pavement/concrete/sr04ch2.cfm>.

- **“International Conference on Best Practices for Ultrathin and Thin Whitetoppings,” *Concrete Pavement Technology Update*, July 2005,** <http://www.fhwa.dot.gov/pavement/concrete/cptu205.cfm>. This issue of the CPTP publication describes a conference on best practices that drew six countries and 26 states; participants indicate the method is widely embraced.

“Mechanical Properties and Durability of Bonded-Concrete Overlays and Ultrathin Whitetopping Concrete,” N. Delatte, A. Sehdev, *Transportation Research Record 1834* (2003), 16-23. Eight overlay mixes were investigated for mechanical properties, and high-strength mixes developed strong mechanical properties more quickly than normal-strength mixes. See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=665522>.

“Mechanical Behavior of Ultrathin Whitetopping Structure Under Stationary and Moving Loads,” T. Nishizawa, Y. Murata, K. Kokubun, *Transportation Research Record 1823* (2003), 102-110. Researchers developed a loading stress determination model and compared results to viscoelasticity formulations for the asphalt pavements being overlaid, and conducted loading tests on the pavements. Findings indicated the interface conditions and asphalt subbase viscosity significantly impact stress resistance in the concrete overlay. See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=663420>.

Transportation Pooled Fund posted solicitation 1068, “Analysis of MnROAD Whitetopping Performance Data for a Module in the Design Guide.” This proposed study is led by Minnesota DOT; partners include Missouri, Mississippi, New York, Pennsylvania and Texas. The study is to run from 2006 through 2009, and focuses on developing a tenable mechanistic design procedure for whitetopping based on evaluation of new construction and forensic evaluation of older installations. It will focus on appropriate use of bonding, as well as calibration for mechanistic-empirical design. See the solicitation at <http://www.pooledfund.org/documents/solicitations/1068.pdf>, and the TPF Web page at <http://www.pooledfund.org/projectdetails.asp?id=1068&status=1>.

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“Comparing the Concrete Pavement Road Map to Research Priorities of WisDOT and Neighboring States,” *Transportation Synthesis Report*, WisDOT Research and Communication Services, October 2006. This report compares the databases of the North Central Pavement Research Coordination Partnership to the Concrete Pavement Road Map. The study categorizes research from Illinois, Michigan, Minnesota and Wisconsin according to CP Road Map research tracks; nine whitetopping reports, with hyperlinks to the studies themselves, are listed under Track 2, as well as another two on concrete overlays. See <http://www.dot.state.wi.us/library/research/docs/tsrs/tsrrigidtoc.pdf>.

Minnesota

A clear leader in design, construction, evaluation and mechanistic design development of whitetopping, Mn/DOT offers a number of reports, state-of-the-practice studies and articles, and other resources. We list a number here. See the Mn/DOT Browse Research Projects page at <http://www.research.dot.state.mn.us/browseresearch.cfm?br=517>.

Construction Report for the MnROAD Thin Whitetopping Test Cells 60-63, Thomas Burnham, Report No. 2006-18, June 2006. This report describes characteristics of new whitetopping test cells as determined by material tests and curl and warp measurements taken during and after construction. The new cells replace seven-year-old ultrathin whitetopping cells. See <http://www.lrrb.org/pdf/200618.pdf>.

Forensic Investigation Report for MnROAD Ultra-thin Whitetopping Test Cells 93, 94 and 95, Thomas Burnham, Report No. 2005-45, September 2005. This report is the study of the test sections described above—93, 94, and 95—that were replaced by cells 60 through 63. High-volume traffic seemed to increase frequency and severity of distress, and thinner sections experienced reflection cracking. See <http://www.lrrb.org/pdf/200545.pdf>.

Synthesis of Current Minnesota Practices of Thin and Ultra-Thin Whitetopping, Braun Intertec Corp., Report No. 2005-27, July 2005. This report describes whitetopping experience in Minnesota, which has ranged from failing to very good. Poor performance was found over short sections of whitetopping that experience stopping trucks, and over thin or poor-condition HMA pavement. Better performance was found over HMA pavement of thick lifts or in good condition; bonding, fiber reinforcement, and joint spacing were found to influence performance. See <http://www.lrrb.org/pdf/200527.pdf>.

The Construction and Performance of Ultra-Thin Whitetopping Intersections on US 169, Julie M. Vandebossche, Report No. 2004-19, May 2003. Three sections of US 169 were rehabilitated with ultrathin whitetopping mixes that included fibers. Distinct cracking in each section showed the importance of asphalt pavement layer support. Compressive strength and flexural strength tests were conducted, and Poisson's ratio and elastic modulus were measured. See <http://www.lrrb.org/pdf/200419.pdf>.

"Performance Analysis of Ultrathin Whitetopping Intersections on US-169," Julie M. Vandebossche, Transportation Research Record 1823 (2003), 18-27. More analysis and test results of the above-mentioned sections of whitetopping on US 169. (This paper won TRB's 2003 Fred Burggraf Award; see announcement at <http://trb.org/am/news/PR/Burggraf.pdf>.) See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=663411>.

"Whitetopping and Hot-Mix Asphalt Overlay Treatments for Flexible Pavement: Minnesota Case History," T. Burnham and D. Rettner, Transportation Research Record 1823 (2003), 3-10. This report describes performance and costs associated with low-volume trunk highway sections of whitetopping and HMA overlay nine years after installation in 1993. Whitetopping sections were performing very well. See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=663409>.

Performance, Analysis and Repair of Ultra-Thin and Thin Whitetopping at Mn/ROAD, Julie M. Vandebossche, Aaron J. Fagerness, Submission to 2002 TRB Annual Meeting.
http://mnroad.dot.state.mn.us/research/mnroad_project/mnroadreports/mnroadonlinereports/performance_analysis_and_repair_of_ultra_thin_and_thin_whitetopping_at_mnroad.pdf
This report reviews construction, design, inspection, testing and repair of MnROAD test cells built in 1997 at various joint space distances. The sections performed well.

"Performance, Analysis, and Repair of Ultrathin and Thin Whitetopping at Minnesota Road Research Facility," Julie M. Vandebossche, Aaron J. Fagerness, Transportation Research Record 1809 (2002), 191-198. This is another version of the TRB paper proposal above. See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=729468>.

"Thin Whitetopping Sections Measure Up at MnROAD," Concrete Products, Feb. 1, 2000. This industry article reviews successes of the 1997 MnROAD whitetopping installations, noting low load-induced tensile strains and crediting corner breaks to thermal gradients within slabs. See http://concreteproducts.com/mag/concrete_thin_whitetopping_sections/.

Mn/DOT Pavement Design Unit.

<http://www.mrr.dot.state.mn.us/pavement/PvmtDesign/pavementdesign.asp>
This Web site provides a link to Mn/DOT whitetopping design documentation.

Colorado

For several years Colorado DOT has been working on mechanistic-empirical design for whitetopping. The following research reports describe some of this effort.

***Instrumentation and Field Testing of Thin Whitetopping Pavement in Colorado and Revision of the Existing Colorado Thin Whitetopping Procedure*, Matthew J. Sheehan, Scott M. Tarr, Shiraz D. Tayabji, Report No. 2004-12, August 2004.** This report details the results of test section installation, instrumentation and review, with a focus on the mechanistic design changes to 1998 whitetopping design guidelines prompted by the analysis. See <http://www.dot.state.co.us/publications/PDFFiles/whitetopping2.pdf>.

***Instrumentation and Field Testing of Whitetopping Pavements in Colorado and Revision of the TWT Design Procedure*, Chung Wu and Matthew Sheehan, Report No. 2002-3 (Interim Report).** This status report looks at a 1996 CDOT project that instrumented whitetopping sections in order to develop mechanistic design procedures for ultrathin whitetopping. The report also looks at new sections built in 2001 for further analysis. See <http://www.dot.state.co.us/publications/PDFFiles/twt.pdf>.

“Mechanistic Design of Thin Whitetopping Pavements in Colorado,” Scott M. Tarr, Matthew J. Sheehan, Ahmad Ardani, *Transportation Research Record 1730* (2000), 64-72. The authors review efforts in Colorado to develop mechanistic design guidelines for whitetopping, including field testing and development of design equations. See the abstract at <http://pubsindex.trb.org/document/view/default.asp?lbid=671714>.

Illinois

Illinois DOT, which employs its own mechanistic-empirical design methodology, has been working with whitetopping for several years. The following Web sites include research as well as project information on all completed whitetopping projects in Illinois.

***Whitetopping Performance in Illinois*, Thomas J. Winkelman, Physical Research Report No. 148, January 2005.** This report reviews field performance of nine experimental whitetopping projects (including four mainline highway pavement rehabilitations) constructed between 1998 and 2004, finding performance in the mainline whitetopping to be excellent. See <http://www.dot.il.gov/materials/research/pdf/148.pdf>.

***Whitetopping Construction and Early Performance in Illinois*, Thomas J. Winkelman, Construction Report, Physical Research Report No. 144, June 2002.** This report reviews seven experimental whitetopping projects in Illinois, including four of mainline asphalt pavements, which all performed well in early analysis. Performance reviews for the thin bonded concrete overlay portions of the intersection projects indicate poor performance. See <http://www.dot.il.gov/materials/research/pdf/144.pdf>.

PCC Man Web Site

<http://www.public.pccman.com>

This site, which is referred to by the Illinois Ready Mix Concrete Association (among other organizations), includes a variety of useful documentation on whitetopping in Illinois. See specifically a database of completed whitetopping projects at http://www.public.pccman.com/Project_List.pdf and Current IDOT UTW & Whitetopping Design Procedures and Specifications at <http://www.public.pccman.com/PR148%20WTUTW%20Final.pdf>.

Iowa

According to a Washington state concrete industry article, Iowa has a significant investment in whitetopping. The article states that Iowa whitetops an average of 19 miles of county and state routes every year. See “‘Ultrathins’ becoming popular” at <http://www.djc.com/special/concrete/10003370.htm>.

***Evaluation of Composite Pavement Unbonded Overlays: Phase III*, James K. Cable, Jennifer L. Morud, Toni R. Tabbert, CTRE Project 01-95, August 2006.** Though focused on design and construction, this report’s performance findings included that for ultra-thin whitetopping, fibers in mixes proved effective in mitigating loss-of-support or multiple cracking in individual slabs; and that standard maintenance crew practices are sufficient to maintain surfaces when isolated panels fail. See the report at http://www.ctre.iastate.edu/reports/composite_unbonded_overlay.pdf and the technical brief at http://www.ctre.iastate.edu/pubs/t2summaries/unbonded_overlay.pdf.

“W-h-i-t-e-t-o-p-p-i-n-g Spells Relief in Iowa,” Gordon Smith, ACPA Downloads. This report describes whitetopping in Iowa, which at the time of publication had been applied to over 300 miles of asphalt pavement in the state. See <http://www.pavement.com/Downloads/RP325P.pdf>.

Michigan

Michigan DOT has been using whitetopping since the late 1990s. The following publications give a glimpse of the Michigan experience.

“Whitetopping Takes on Trucks in Michigan,” *Concrete Pavement Progress*, Vol. 40 (3), August 2004, pages 6-7. Concrete whitetopping helped a Michigan county road commission solve a severe rutting problem on asphalt pavement near Interstate 75. A local road frequented by large trucks got a 7-inch concrete inlay, which solved the rutting problem and has shown minimal wear after its first winter in service. See <http://www.pavement.com/CPP/2004/CPP-080604.pdf>.

“Thin Whitetopping: Rehabilitation Alternative,” *Construction and Technology Research Record*, No. 93, October 2001. Michigan puts the performance-based service life expectancy of whitetopping at 20 years or more. See <http://www.michiganltap.org/pubs/mrr/pdf/r93.pdf>.

“Ultra-thin Whitetopping: The State-of-the-Practice for Thin Concrete Overlays of Asphalt,” *US Roads Journal*, 2001. (This is a reprint of a Michigan Technological University publication.) This article briefly reviews Michigan’s experience with the technology in the late 1990s. See <http://www.usroads.com/journals/rmej/0104/rm010402.htm>.

Whitetopping Project on M-46 Between Carsonville and Port Sanilac, Michael J. Eacker, Research Report R-1387, July 2000. This report describes the first Michigan DOT whitetopping project, built alongside a hot-mix asphalt project for comparison. For separate links to the report and to the appendices, see http://www.michigan.gov/mdot/0,1607,7-151-9622_11045_24249-67091--,00.html.

Other States

These citations describe whitetopping efforts in Indiana and Missouri:

Indiana. “Analysis of Performance of the Ultra-Thin Whitetopping Subjected to Slow Moving Loads in an Accelerated Pavement Testing Facility,” Sudarshan Rajan, Jan Olek, Thomas L. Robertson, Khaled Galal, Tommy Nantung, and W. Jason Weiss, 7th *International Conference on Concrete Pavements*, Orlando, Florida, September 9-13, 2001. This report describes the performance of an ultra-thin whitetopping installation at Indiana DOT’s Accelerated Pavement Testing site in 1999. An analysis of stresses and strains in the overlay under repeated loading considered maximum strains and locations, and bonding with existing pavement in order to develop design guidelines. See <http://rebar.ecn.purdue.edu/APT/Research/S16-P4-Rajan.pdf>.

Missouri. *Evaluation of Ultra-Thin Whitetopping*, Dave Amos, MoDOT, Research Investigation RI99-012, October 2001. The researchers conducted field and laboratory testing of a whitetopping project that entailed coldmilling before a three-inch overlay, and found the overlay’s performance in its first six months to be promising. See <http://168.166.124.22/RDT/reports/Ri99012/RDT01014.pdf>.

Industry

Two pavement industry sites offered useful links to articles and design guides on whitetopping:

The Transtec Group—Whitetopping, Links of Interest. This site is a portal to various Web pages devoted to whitetopping, its practice, comparative strengths, various materials used in mixes, and more. Links of interest include those to Ohio and Iowa specifications, respectively, as well as to whitetopping’s specifications as a rehabilitation method in the AASHTO M-E Design Guide. See <http://www.whitetopping.com/links.asp>.

American Concrete Pavement Association. The ACPA Web site features a variety of articles and links on whitetopping around the country. See <http://www.pavement.com/>. Relevant pages include:

- **The U.S. Experience with Ultra-Thin Whitetopping, ACPA.** http://www.pavement.com/Concrete_Pavement/Technical/Fundamentals/Overlays_of_Asphalt_Pavement.asp.
- **Concrete Pavement Resurfacing.** This page offers a quick description of concrete overlay technologies, including ultra-thin whitetopping. http://www.pavement.com/Concrete_Pavement/Technical/Fundamentals/Concrete_Pavement_Resurfacing.asp.
- **UTW Calculator.** This page provides a load-carrying capacity calculator for whitetopping. http://www.pavement.com/Concrete_Pavement/Technical/UTW_Calculator/index.asp.